

**Modified Enlarged 18pt**

**OXFORD CAMBRIDGE AND RSA EXAMINATIONS**

**Monday 18 January 2021 – Morning**

**Level 3 Cambridge Technical in Applied Science**

**05848/05849/05874**

**Unit 3: Scientific analysis and reporting**

**Time allowed: 2 hours plus your additional time allowance**

**You must have:**

**a ruler (cm/mm)**

**the Insert**

**a copy of the Periodic Table**

**You can use:**

**a scientific or graphical calculator**

**an HB pencil**

**Please write clearly in black ink.**

**Centre  
number**

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**Candidate  
number**

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**First name(s)** \_\_\_\_\_

**Last name** \_\_\_\_\_

**Date of  
birth**

D	D	M	M	Y	Y	Y	Y
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**READ INSTRUCTIONS OVERLEAF**

## **INSTRUCTIONS**

**Use black ink. You can use an HB pencil, but only for graphs and diagrams.**

**Write your answer to each question in the space provided. If you need extra space use the lined pages at the end of this booklet. The question numbers must be clearly shown.**

**Answer ALL the questions.**

## **INFORMATION**

**The total mark for this paper is 100.**

**The marks for each question are shown in brackets [ ].**

**The Periodic Table is supplied separately.**

## **ADVICE**

**Read each question carefully before you start your answer.**

**BLANK PAGE**

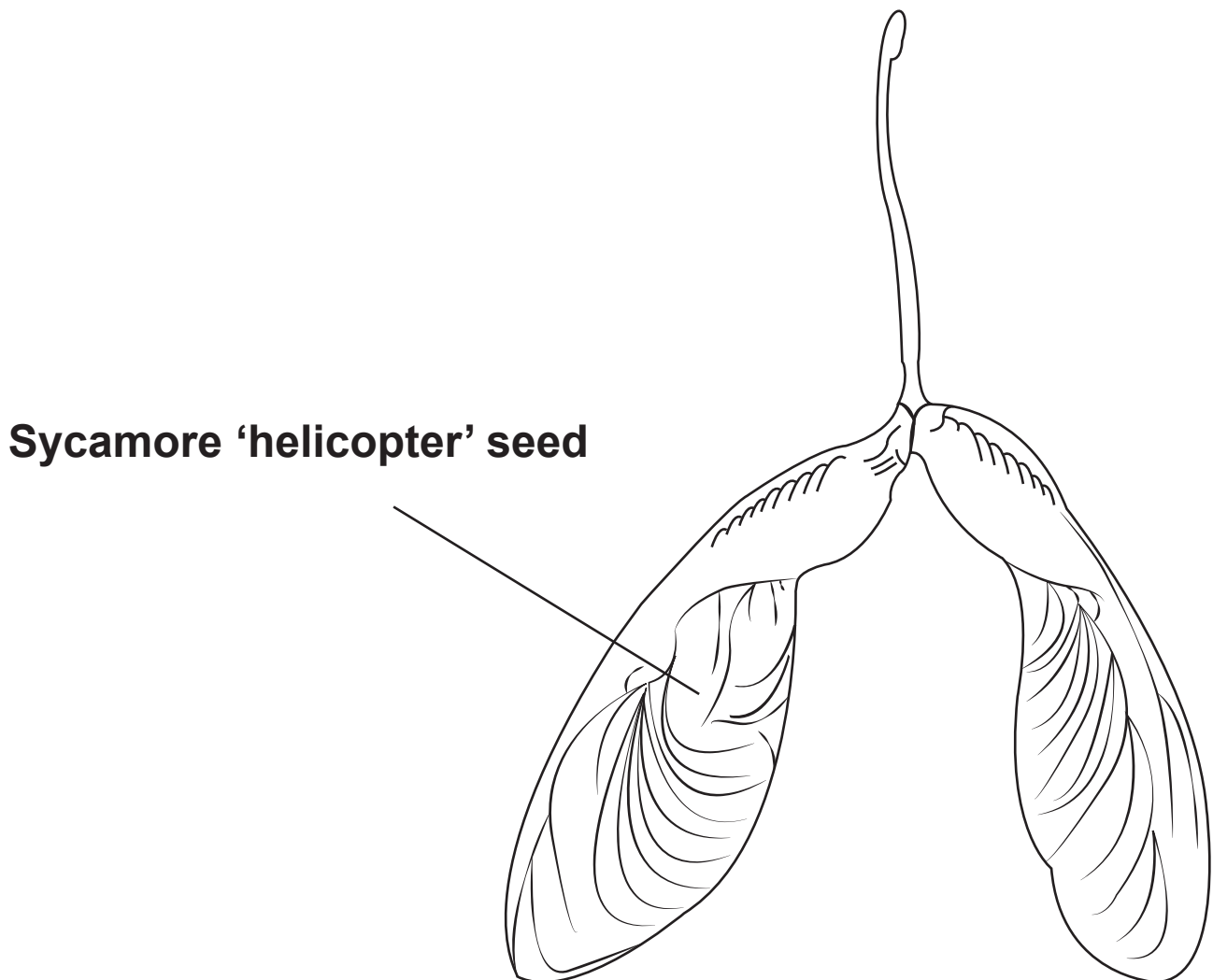
**Answer ALL the questions.**

- 1 Alex is investigating the dispersal of seeds from a sycamore tree.**

**Sycamore seeds are wing shaped as shown in FIG. 1.1.**

**Their shape causes them to spin away from the tree as they fall through the air.**

**FIG. 1.1**

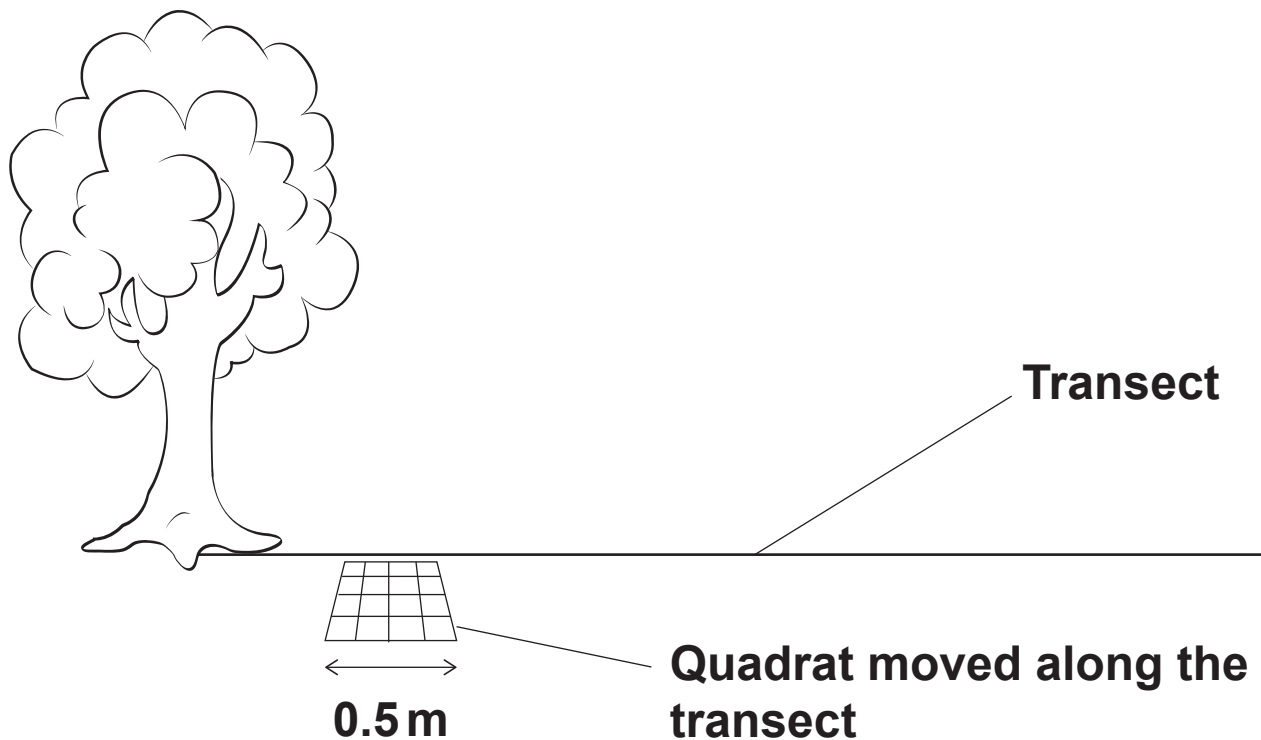


**Alex counts the number of seeds in quadrats on one side of a 10 m line transect.**

The quadrat used is a wire square-shaped grid ( $0.5 \times 0.5$  m) divided into 100 equal sections. The sections make it easier for Alex to count the seeds.

FIG. 1.2 is a diagram of Alex's method.

**FIG. 1.2**



Alex's results are shown in TABLE 1.1.

**TABLE 1.1**

Distance from tree along the transect line (m)	1	2	3	4	5	6	7	8	9	10
Number of sycamore seeds in each quadrat	39	36	27	18	16	16	10	12	3	0

Number of seeds per quadrat	Abundance rating
28 or more	5
22 to 28	4
15 to 21	3
8 to 14	2
1 to 7	1

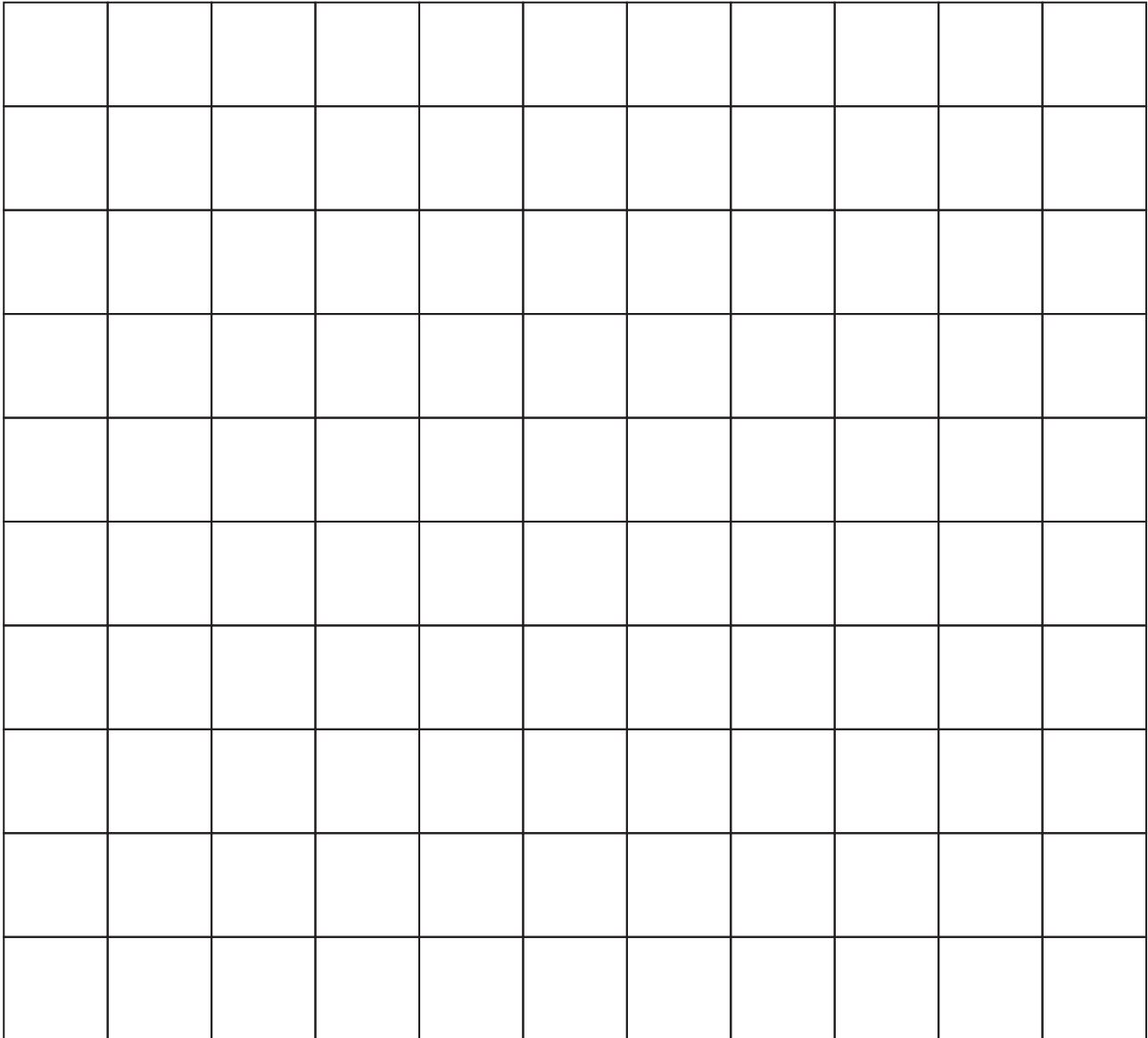
- ### TABLE 1.3

[illegible]

- (ii) Use your answer in TABLE 1.3 to draw a kite diagram on the grid in FIG. 1.3.

Your kite diagram should show how the abundance rating of sycamore seeds varies with distance from the tree. [4]

**FIG. 1.3**



**(b) Alex repeats his investigation.**

**He places the transect line in different directions around the tree and counts the number of sycamore seeds in the quadrat along the length of each position of the transect line.**

**Alex then calculates the number of seeds in each direction as a percentage of the total number of seeds in all directions.**

**His results are shown in TABLE 1.4.**

**TABLE 1.4**

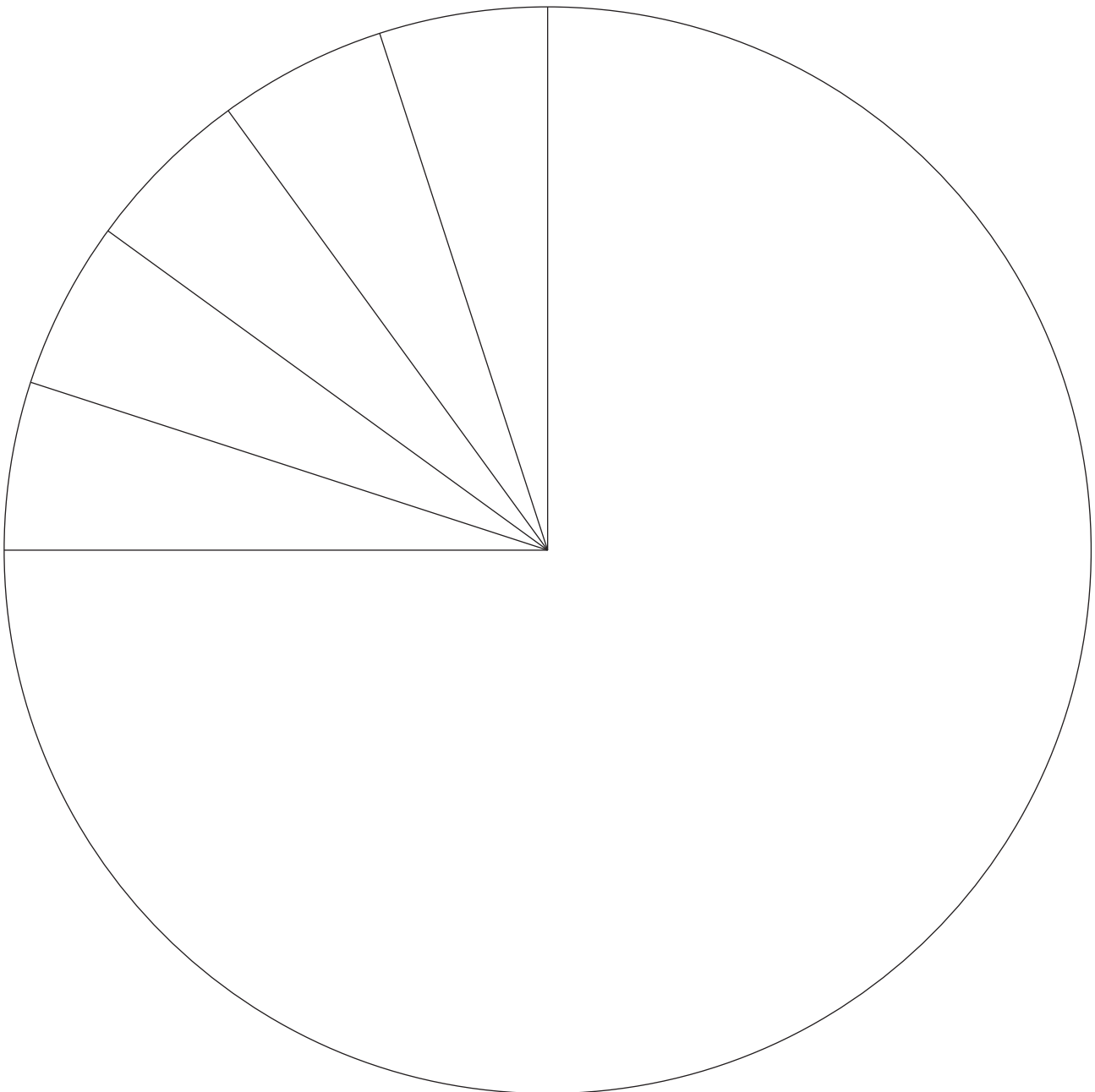
<b>Direction</b>	<b>Percentage of total number of seeds</b>
<b>north (0°)</b>	<b>5</b>
<b>north-east (45°)</b>	<b>40</b>
<b>east (90°)</b>	<b>25</b>
<b>south-east (135°)</b>	<b>10</b>
<b>south (180°)</b>	<b>5</b>
<b>south-west (225°)</b>	<b>5</b>
<b>west (270°)</b>	<b>5</b>
<b>north-west (315°)</b>	<b>5</b>



**Complete the pie chart in FIG. 1.4 to show the percentage of seeds in the NORTH-EAST, EAST and SOUTH-EAST directions.**

**Label these three sectors. [3]**

**FIG. 1.4**



- (c) Alex looks online for an explanation of the seed dispersal.

Please refer to FIG. 1.5 in the Insert. He finds the chart in FIG. 1.5 in a journal about UK weather.

He knows that wind blowing from one direction will blow seeds in the opposite direction.

For example, wind from the south-west will blow seeds in the north-east direction.

- (i) Use the data in FIG. 1.5 in the Insert to complete the sentence.

In April and \_\_\_\_\_  
there is a \_\_\_\_\_ %  
chance that the wind will be blowing from either the  
north-east or the \_\_\_\_\_. [3]

- (ii) Discuss whether the evidence in FIG. 1.5 in the Insert explains the data in TABLE 1.4. [5]

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(iii) Identify which **THREE** of the following are **MOST** likely to make a conclusion more secure.

Tick (✓) **THREE** boxes. [3]

Obtain frequency data for other wind directions.

☐

Repeat the method in FIG. 1.2 and find the average.

☐

Repeat the measurements in TABLE 1.4 using more directions.

☐

Collect seed dispersal data from different tree species.

☐

Collect seed dispersal data from more than one year.

☐

Obtain wind direction frequency data from more than one year.

☐

- (d) Describe the conflicting evidence in TABLE 1.4 and FIG. 1.5 in the Insert.

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[2]

2 Mia is an astrophysicist.

She studies the relationship between the size of stars and their temperatures.

- (a) To calculate the volume of a star Mia uses the formula: Volume of star =  $\frac{4}{3}\pi r^3$

- (i) Determine the value of  $\frac{4}{3}\pi$  as a decimal.  
Give your answer to 2 significant figures.

$\frac{4}{3}\pi =$  \_\_\_\_\_ [2]

- (ii) The average radius,  $r$ , of the Sun is  $7.0 \times 10^8 \text{ m}$ .

Calculate the volume of the Sun.

Give your answer in STANDARD FORM.

Volume of the Sun = \_\_\_\_\_  $\text{m}^3$  [3]

- (iii) The mass of the Sun is  $2.0 \times 10^{30} \text{ kg}$ .

Calculate the density of the Sun.

Use your answer to (a)(ii) and the equation:  
 $\text{mass} = \text{volume} \times \text{density}$ .

Give your answer to 2 significant figures  
and give the SI unit of density.

Density of the Sun = \_\_\_\_\_ unit \_\_\_\_\_ [3]

- (b) Astronomers measure star brightness in terms of luminosity and magnitude.

Luminosity is the amount of light that a star emits from its surface.

Magnitude is a measure of how bright the star appears. The lower the magnitude, the brighter is the star.

The Sun is a main sequence star.

Please refer to FIG. 2.1 in the Insert. The two charts in FIG. 2.1 show the relationships between some of the physical properties of main sequence stars.

- (i) Complete the following sentences to describe the trends in FIG. 2.1 in the Insert.

Choose from the following list of words.

You may use each word once, more than once, or not at all.

blue	negative
bright	neutral
colour	positive
faint	red
increases	temperature
magnitude	

As the \_\_\_\_\_ of main  
sequence stars becomes increasingly positive, their colour  
changes from \_\_\_\_\_ to  
\_\_\_\_\_.

As their \_\_\_\_\_ increases, their  
luminosity changes from \_\_\_\_\_  
to \_\_\_\_\_. [4]

- (ii) Mia studies White Dwarf stars. These are the  
remnants of main sequence stars.  
White Dwarf stars are in the region below and  
to the left of the main sequence stars in both  
charts in FIG. 2.1 in the Insert.

Use the information shown in FIG. 2.1 to  
describe White Dwarf stars.

\_\_\_\_\_  
\_\_\_\_\_  
\_\_\_\_\_  
\_\_\_\_\_ [2]

- (c) Please refer to FIG. 2.2 in the Insert. Only main sequence stars within a certain range of mass become White Dwarfs.

The relationship between the mass of a White Dwarf (compared to the Sun) and its radius (compared to the Sun) is shown in FIG. 2.2 in the Insert.

- (i) Use FIG. 2.2 in the Insert to determine the radius (compared to the Sun) of a White Dwarf formed by a star with a mass of 1.0 (compared to the Sun).

Radius (compared to the Sun) = \_\_\_\_\_ [1]

- (ii) Calculate the volume of a White Dwarf with the same mass as the Sun as a percentage of the Sun's volume.

Percentage volume = \_\_\_\_\_ % [3]



- (iii) Describe the trend shown by the graph in FIG. 2.2 in the Insert.**

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**[1]**

- (iv) Beyond a certain mass, a White Dwarf collapses forming a Black Hole.**

**Use the graph in FIG. 2.2 in the Insert to determine the upper limit to the mass of a White Dwarf.**

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**[1]**

**3 Fungi are classified into different families.**

**One family is called Agaricaceae.**

**Please refer to FIG. 3.1 in the Insert. FIG. 3.1 shows some of the structural features of Agaricaceae fungi.**

**(a) Please refer to TABLE 3.1 in the Insert. Use the information in TABLE 3.1 to complete the sentences below.**

**The gills of the fungus shown in FIG. 3.1 do NOT extend to the base of the stipe (stem).**

**This means that the hymenium CANNOT be**

**\_\_\_\_\_ .**

**The cap of the fungus in FIG. 3.1 is the same shape as fungi with a \_\_\_\_\_ hymenium.**

**The stipe (stem) of the fungus in FIG. 3.1 is the same shape as fungi with a \_\_\_\_\_ hymenium. [3]**

**(b) Suggest THREE reasons why biologists use dichotomous keys.**

**1** \_\_\_\_\_

\_\_\_\_\_  
**2** \_\_\_\_\_

\_\_\_\_\_  
**3** \_\_\_\_\_

\_\_\_\_\_  
**[3]**

**(c) Please refer to TABLE 3.2 in the Insert.  
TABLE 3.2 shows some of the habitats and features of different fungi.**

**You will need to refer to FIG. 3.1 and TABLE 3.1 which are in the Insert to see the different types of stipe (stem) and hymenium.**

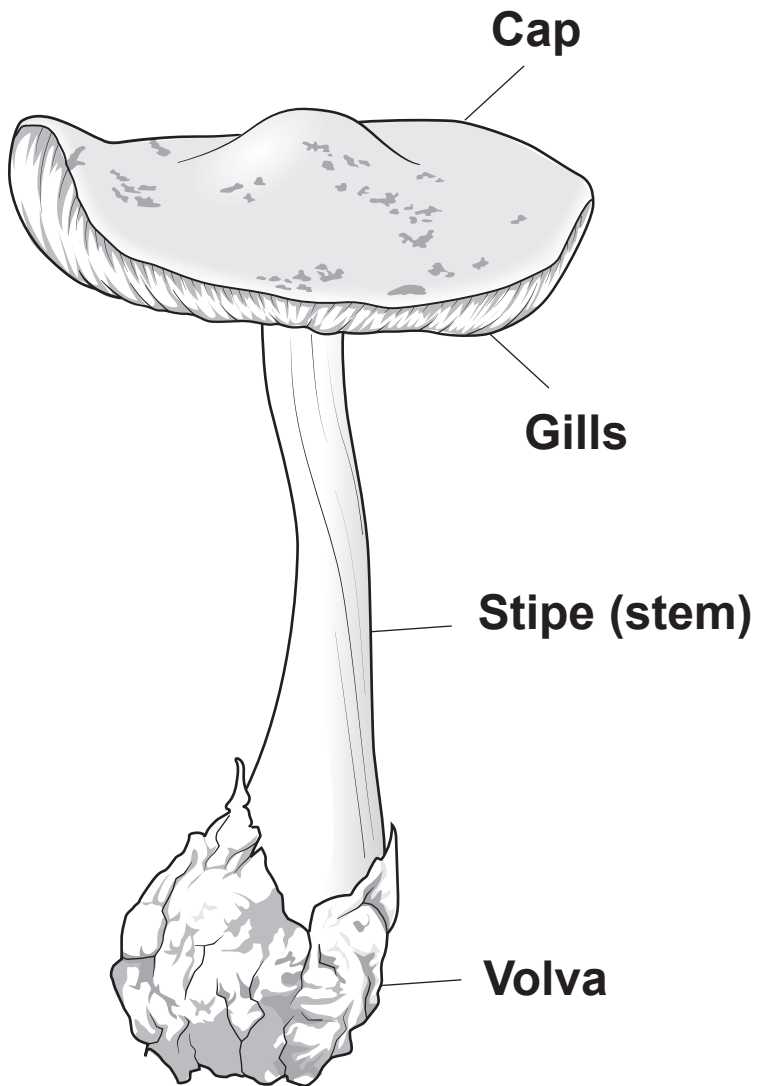
**Use the information in TABLE 3.2 to complete the blank spaces in the key in FIG. 3.2 in the Insert.**

**Give the FEATURE of the fungus in the blank GREY rectangles.**

**Give the FUNGUS NAME in the blank UNSHADED rectangles. [5]**

(d) A fungus described in TABLE 3.2 in the Insert is shown in FIG. 3.3.

**FIG. 3.3**



- (i) Please refer to TABLE 3.2 and FIG. 3.2 in the Insert. Use TABLE 3.2 or the KEY in FIG. 3.2 to identify the name of the fungus shown in FIG. 3.3.

Tick (✓) ONE box. [1]

*Amanitopsis vaginata*

☐

*Entoloma cetratum*

☐

*Galerina marginata*

☐

*Lepiota procera*

☐

- (ii) The names of the fungi in TABLE 3.2 in the Insert are based on binomial nomenclature.

Describe the key features of binomial nomenclature and ONE advantage of using this naming system.

Key features \_\_\_\_\_

\_\_\_\_\_

Advantage \_\_\_\_\_

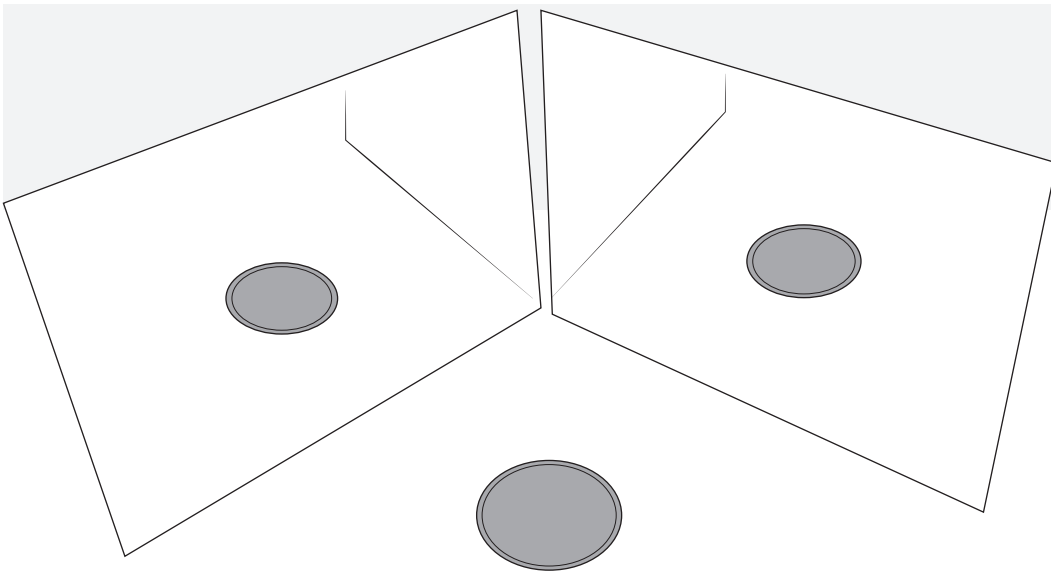
\_\_\_\_\_

[2]

- 4 Eve is investigating reflections in plane mirrors.**  
**She places a coin between two mirrors.**

**FIG. 4.1 shows the coin and two images of the coin reflected in the mirrors.**

**FIG. 4.1**



**Eve adjusts the angle between the mirrors.**

**She observes that there is a range of angles between which whole images first appear and just before another image begins to appear.**

**(a) Identify what Eve needs to specify to ensure that her investigation is repeatable.**

**Tick (✓) THREE boxes. [3]**

**The range of angles between the mirrors.**

☐

**The diameter of the coin.**

☐

**The distance between the coin and the junction between the mirrors.**

☐

**The position of the observer relative to the mirrors.**

☐

**The number of images.**

☐

**The surface area of the mirrors.**

☐

**The thickness of the coin.**

☐

- (b) Eve starts her investigation with the two mirrors at an angle of  $180^\circ$ .

As she reduces the angle between the mirrors from  $180^\circ$  to  $166^\circ$ , Eve observes one image of the coin.

When she reduces the angle to  $165^\circ$ , a second image starts to appear.

She continues to reduce the angle between the mirrors until a third image begins to appear.

She measures this angle to be  $98^\circ$ .

- (i) Describe the relationship between the variables.

---

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[2]

- (ii) Determine the range and interval of angles for the appearance of two images.

Range = \_\_\_\_\_

Interval = \_\_\_\_\_

[2]





- (c) Eve finds this formula for the number of images  $n$  formed between two plane mirrors:

$$n = \frac{360}{\theta} - 1$$

where  $\theta$  is the angle between the mirrors.

- (i) Use the formula to determine the angle of  $\theta$  that gives two whole images.

$\theta =$  \_\_\_\_\_  $^{\circ}$  [1]

- (ii) Calculate the number of images which (according to the formula) should be produced when the angle between the mirrors is  $165^{\circ}$ .

Give your answer to 1 decimal place.

Number of images = \_\_\_\_\_ [1]

- (iii) Calculate the error of the observed angle,  $98^\circ$ , as a percentage of the angle calculated in (c)(i).

Use the equation:

$$\text{Percentage error} = \frac{O - A}{A} \times 100$$

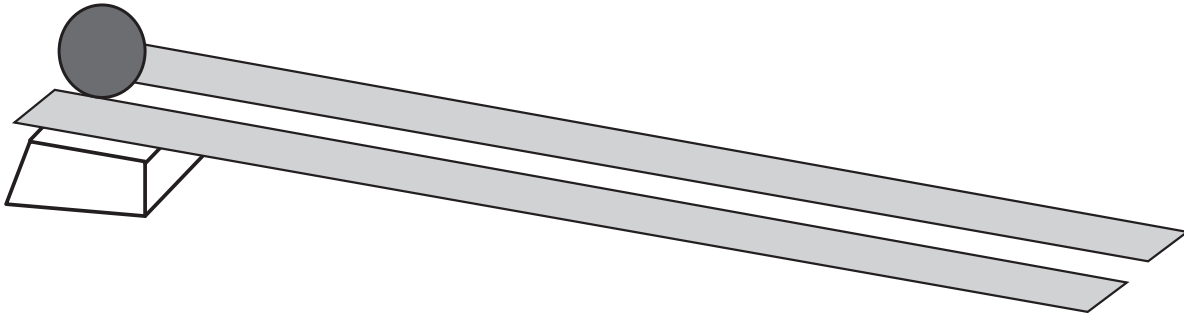
where A is the calculated angle in (c)(i), and O is the observed angle.

Percentage error of  $98^\circ$  = \_\_\_\_\_ % [2]

- 5 Kai is investigating how the angle  $\theta$  of a sloping track affects the acceleration  $a$ , of a glass ball as it rolls down the track.

The track is shown in FIG. 5.1.

FIG. 5.1



Before he starts the investigation, he uses this equation to calculate some theoretical results:

$$a = g \sin \theta$$

This equation determines the horizontal component of the acceleration.

Kai uses a value of the acceleration due to gravity,  $g = 10 \text{ ms}^{-2}$ .

He then plots these results on the graph in FIG. 5.2 in the Insert.

- (a) (i) On FIG. 5.2 in the Insert, draw a curve of best fit. [1]
- (ii) Use your curve to determine the acceleration of the ball on a track with an angle of slope  $\theta = 20^\circ$ .

Acceleration = \_\_\_\_\_  $\text{ms}^{-2}$  [1]

- (iii) Calculate the gradient of the curve of best fit when the angle of the slope is  $55^\circ$ .

Show your working on FIG. 5.2 in the Insert.

Gradient at  $55^\circ$  = \_\_\_\_\_ [3]

- (b) Suggest TWO reasons why Kai's theoretical results are NOT accurate.

1 \_\_\_\_\_

\_\_\_\_\_

2 \_\_\_\_\_

\_\_\_\_\_

[2]

- (c) Suggest why Kai produces theoretical results to compare with the actual results of his investigation.

\_\_\_\_\_

\_\_\_\_\_ [1]

**6 Jack is a technician working in a food science laboratory.**

**(a) Jack uses a colorimeter to determine the mass of iron in 100 g of spinach leaves.**

**He knows that when ammonium thiocyanate is added to a solution containing  $\text{Fe}^{3+}$  ions, a red complex is formed.**

**Jack obtains a calibration graph by following four steps:**

**STEP 1 He puts  $2\text{ cm}^3$  of water in a cuvette in the colorimeter and adjusts the absorbance reading to give a value of zero.**

**STEP 2 He prepares 5 solutions of iron(III) chloride of known concentrations as shown in TABLE 6.1.**

**STEP 3 He takes  $10\text{ cm}^3$  of each solution, adds  $10\text{ cm}^3$  of ammonium thiocyanate and mixes thoroughly so that the red colour is evenly distributed.**

**STEP 4 He records the absorbance of  $2\text{ cm}^3$  of each solution as shown in TABLE 6.1.**

**TABLE 6.1**

<b>Concentration of <math>\text{Fe}^{3+}/\text{mg dm}^{-3}</math></b>	<b>Absorbance</b>
<b>2.6</b>	<b>0.19</b>
<b>5.2</b>	<b>0.58</b>
<b>7.8</b>	<b>0.67</b>
<b>10.4</b>	<b>0.89</b>
<b>13.0</b>	<b>1.11</b>

- (i) Refer to FIG. 6.1 in the Insert. Plot a graph of concentration of  $\text{Fe}^{3+}$  (x-axis) against absorbance (y-axis). [4]
- (ii) Draw a line of best fit on the graph and circle the outlier. [2]

- (b) Jack then uses his calibration graph to find the amount of iron in spinach leaves.

He gently heats 3.60 g of spinach leaves until they have all burnt.

He adds 10 cm<sup>3</sup> of water and filters the mixture to remove the ash.

He then adds 10 cm<sup>3</sup> of ammonium thiocyanate solution to the 10 cm<sup>3</sup> of spinach extract and measures the absorbance.

He finds that the **ABSORBANCE VALUE** is 0.70.

Use the following steps to calculate the mass of iron in 100 g of spinach leaves.

- (i) Use the graph which is FIG. 6.1 in the Insert to determine the concentration of iron (in mg dm<sup>-3</sup>) in the spinach extract.

Show your working on the graph.

Concentration of iron = \_\_\_\_\_ mg dm<sup>-3</sup> [1]



- (ii) Your answer to (b)(i) is the number of mg of iron in  $1000\text{ cm}^3$  of the solution.

Use this value to calculate the mass of iron in  $10\text{ cm}^3$  of the spinach extract.

Mass of iron in  $10\text{ cm}^3$  of the spinach extract =

\_\_\_\_\_ mg [1]

- (iii) Jack uses  $3.60\text{ g}$  of spinach leaves in his experiment.

Use your answer to (b)(ii) to calculate the mass in mg of iron in  $100\text{ g}$  of spinach leaves.

Mass of iron in  $100\text{ g}$  of spinach leaves =

\_\_\_\_\_ mg [1]

- (c) The recommended dietary allowance (RDA) of iron in an average person's diet is 14 mg.

Calculate what percentage of the RDA of iron an average person will get by eating 100 g of the spinach leaves used in Jack's experiment.

Percentage of the RDA of iron = \_\_\_\_\_ % [1]

- (d) Another technician, Amaya, carries out a titration experiment to compare the vitamin C content of three fruit juices.

One way to determine the amount of vitamin C is to carry out a redox titration using a standard solution of iodine.

When iodine solution is gradually added to a solution containing vitamin C in the presence of starch indicator, iodine is converted to iodide ions.

Once all the vitamin C in the sample has been used up, any further addition of iodine will not react. This excess iodine reacts with starch to form a blue-black complex.

The endpoint of the titration is when the blue-black colour first appears.

Amaya is provided with three different fruit juices, a standard solution of iodine and some starch solution.

**She has access to normal glassware apparatus needed for carrying out a titration.**

**Describe the steps Amaya should follow to find out which fruit juice contains the highest concentration of vitamin C.**

**In your answer include the names of the apparatus Amaya should use.**

[illegible]

- 7 Scientific journal publications contain peer-reviewed articles. Such articles often contain tables of data.**

**FIG. 7.1 opposite is an example of a table taken from an article which evaluates three different cell counting methods.**

**The three cell counting methods used were:**

**a manual method using a hemocytometer**

**a semi-automated method using a Countess cell-counter**

**a fully automated method using a Vi-Cell analyser.**

- (a) Give ONE reason why a table is a useful way to show this kind of information.**

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**[1]**

- (b) Suggest why the authors of the research article have included references in the table.**

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**[1]**

FIG. 7.1

Cell counting system	Auto sample	Staining options	Size range (µm)	Sample volume (µL)	Concentration range (cells/mL)	Imaging technology
Hemocytometer a,b,c	No	Erythrosin B, Nigrosin, Safranin, Methylene blue and Trypan blue	Undefined	50	2.5x10 <sup>5</sup> 8.0x10 <sup>6</sup>	Microscope objective 40x
Countess cell-counter	No	Trypan blue	8-60	20	1x10 <sup>4</sup> 1x10 <sup>7</sup>	Camera 2.3x objective and 3.1 Megapixel
Vi-Cell® analyser	Yes	Trypan blue	2-70	500	5x10 <sup>4</sup> 1x10 <sup>7</sup>	Auto-focus routine firewire camera 1394x 1040CCD array

**a** Bastidas O. Cell counting with Neubauer chamber. Technical note. Celeromics 1-6

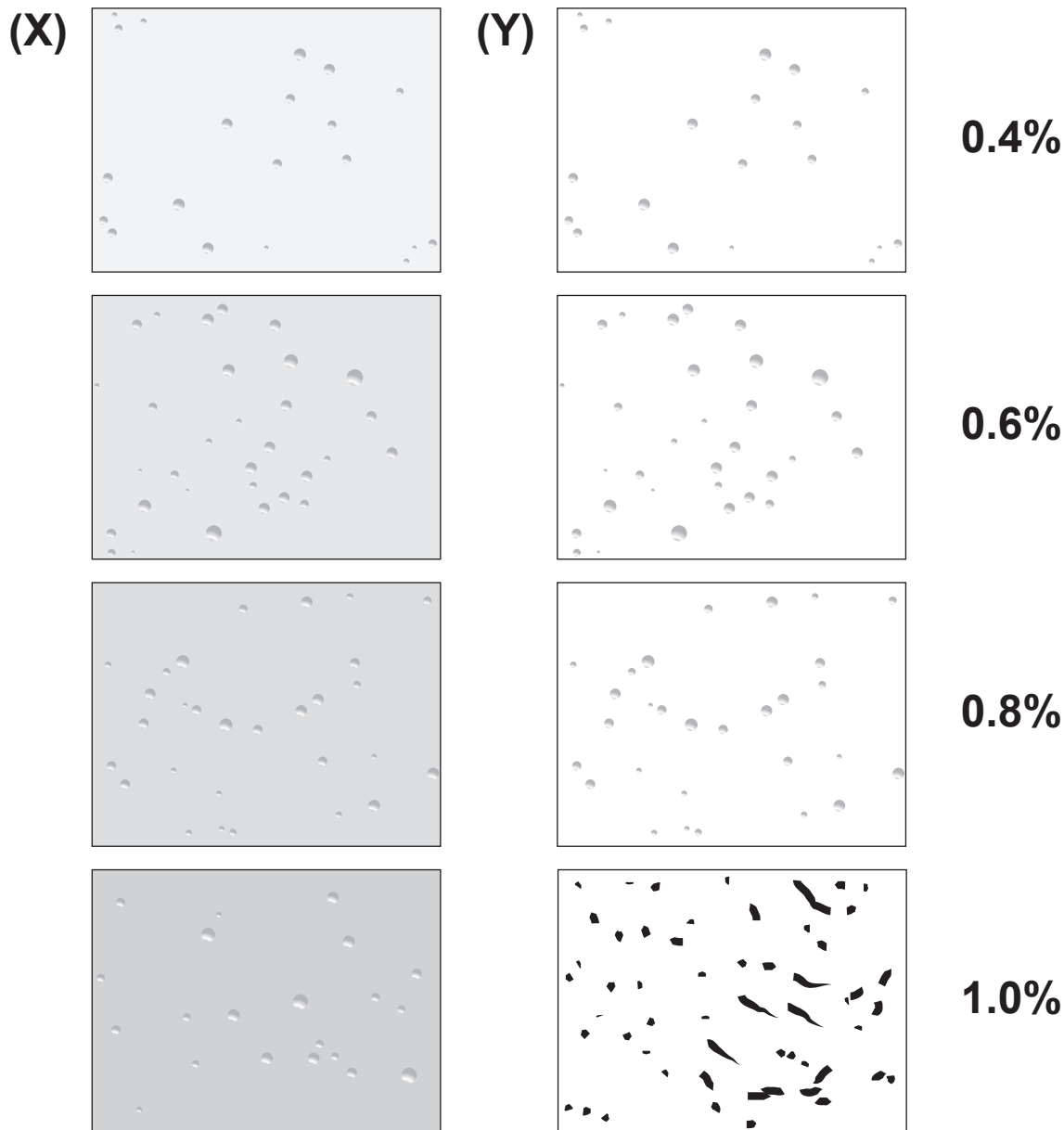
**b** Hsiung F McCollum T, Hefner E and Rubio T. Comparison of count reproducibility, accuracy, and time to results between a hemocytometer and TC20™ Automated cell counter. Technical note: Bio-Rad Laboratories, Inc., 2013.

**c** Maruhashi F, Murakami S, Baba K. Automated monitoring of cell concentration and viability using image analysis system. Cytotechnology 1994; 15: 282-289.

(c) The authors presented some of their data in photographic form.

An example of this form of data presentation is shown in FIG. 7.2.

**FIG. 7.2**



**Comparison of images produced using the Countess cell-counter with different concentrations of the staining solution.**

**(X) shows images from the camera, (Y) represents images as analysed by computer software.**

**State TWO advantages of presenting data in photographic form in a scientific publication.**

1

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2

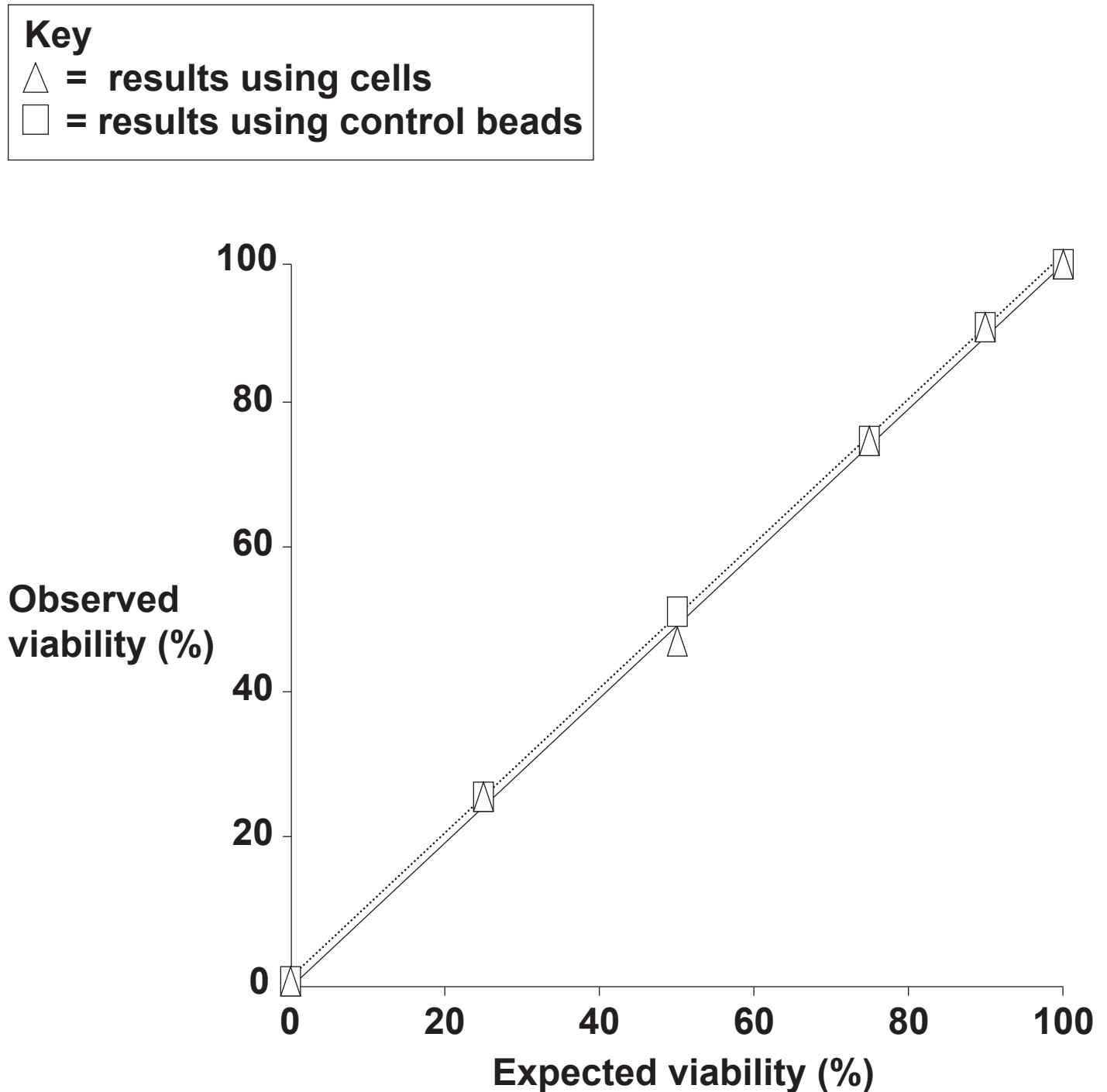
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**[2]**

(d) Data can also be presented graphically.

One of the graphs included in the research paper is shown in FIG. 7.3.

FIG. 7.3





**Suggest TWO reasons why the authors chose to show the data in FIG. 7.3 graphically.**

- 1 \_\_\_\_\_
- 2 \_\_\_\_\_
- [2]**

**(e) In addition to tables, photographs and graphs, data can be recorded in other ways.**

**List TWO other ways that scientific data can be recorded.**

- 1 \_\_\_\_\_
- 2 \_\_\_\_\_
- [2]**

**(f) In terms of scientific data, explain the meaning of validity and accuracy.**

**Validity** \_\_\_\_\_

**Accuracy** \_\_\_\_\_

**[2]**

**END OF QUESTION PAPER**

**If additional answer space is required, you should use the following lined pages. The question numbers must be clearly shown in the margins.**

This image shows a single page of white paper with horizontal blue ruling lines. The lines are evenly spaced and run across the width of the page. There is no handwriting or other markings on the paper.





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